

Medical-geographical and radiological aspects of the system “environment – population health”

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Abstract. The article is devoted to the problems of study of medical and ecological risks of the territory taking into account the state of the environment.

At present, the study of health and environmental risks in Ukraine and its regions is relevant today, given the current demographic situation and the dynamics of morbidity among the population. In connection with this, geographic studies of the medical and environmental risks of the territory acquire special significance.

The research uses general scientific methods, among them traditional (synthesis, analysis, comparisons, methods of induction, deduction, observation, abstraction, generalization) and modern (system analysis and synthesis). The most commonly used and universal is the systematic method, since medical and geographical research is inherently complex.

In determining the medical-ecological risk of the territory among a complex of natural indicators and anthropogenic factors of environmental impact, we included a specific violation of the quality of the environment in the north of the Rivne Oblast after the Chernobyl disaster.

The results of the study suggest a high correlation between soil contamination by radionuclides of territories (especially the northern ones) in the Eastern part of the Southwest region of Ukraine and the incidence of endocrine diseases in the regions concerned.

The theoretical value of the obtained results is to deepen theoretical knowledge about the existing interconnections in the system “environment – health of the population”.

The practical value of the results of the study is to apply the method of express assessment of the medical and geographical condition of the territory for the development of plans for the development of the region in accordance with the minimization of health and environmental risks for the population.

Key words: environment; medical-geographical research; medical-ecological risks; perception; contamination with radionuclides.

1. Introduction

Sustainable human development (*human development*) is one of the most important components of the sustainability of the country's overall development. To create a model of sustainable development of the region, an important issue is the study of the system “environment – public health”.

When analyzing the quality of the environment in terms of the impact on the health of the population, safety of residence in the study area, the main stage is the assessment of

medical and environmental risk, which is the probability of occurrence of diseases of the population of the study area.

At present, the study of health and environmental risks in Ukraine and its regions is relevant today, given the current demographic situation and the dynamics of morbidity among the population. In connection with this, geographic studies of the medical and environmental risks of the territory acquire special significance.

Significant contribution in this direction was made by O.P. Avtsin (Institute of Human Morphology, Academy

of Medical Sciences of the Russian Federation), M.I. Budiko (State Hydrological Institute, St. Petersburg), V.M. Gutsulyak (Chernivtsi National University, Ukraine), I.I. Datsenko (Lviv Medical University), A.A. Keller (Department of Medical Geography of the Russian Geographical Society), I.A. Khlebovich (Institute of Water and Environmental Problems of the Siberian Branch of the RAS), Yu.S. Kushniruk (National University of Water Management and Nature Management in Rivne, Ukraine), G.P. Oblapenko and B.V. Vershinsky (Research Institute of Pasteur Epidemiology and Microbiology, St. Petersburg), V.M. Paschenko (National University of Bioresources and Natural Resources of Ukraine), A.G. Popov (Moscow State University), B.B. Prokhorov (Institute of Geography of the RAS), S.V. Ryaschenko (Institute of Geography of Siberia and the Far East), V.O. Shevchenko (Kyiv National University), L.T. Shevchuk (Lviv National University), O.O. Shoshin (Military Medical Academy, St. Petersburg), O.H. Voronov (Department of Biogeography of the Faculty of Geography, Moscow State University), and others.

In the analysis of thematic maps of the morbidity of the population and environmental pollution (the method of cartographic modeling was used) it was established that the territorial distribution of the morbidity of the population (in particular, the general one) closely correlates with the level of ecosituation in Ukraine (Baranovskiy et al., 1995; Baranovskiy, 2000; Mezentsseva et al., 2018), and in particular in the Chernivtsi region (Hutsuliak, 1997), Khmelnytsky region (Romaniv, 2003), Ternopil region (Iankovska, 2010), Kharkiv oblast (Niemets et al., 2009), Vinnitsa region (Martusenko, 2005) and other regions of Ukraine. Abroad, in particular in Russia, such studies were conducted in the Irkutsk region (Rotanova & Khlebovych, 2001).

2. Study Area

It should be noted that the northern territory of the Rivne region was identified as a region of negative natural and ecological status, even in the nineteenth century (Zhylynskyi, 1899).

For many centuries, Polissya – an inaccessible swampy area, most of which was located in the territories of the Minsk, Grodno and Volyn provinces, was considered hopeless for economic development. Another ancient historian and philosopher Herodotus, rising along the Dnieper and Pripyat and seeing the water of Polissya, wrote: "... This is the land of seas and fogs ...". It was an extreme of wildlife with scattered and underdeveloped lands. A noticeable settlement and development of a man suitable for living Polissya sites began with the XVII century (Korotun, 2007).

The beginning of active and planned work on the drainage of land in our region can be considered the order of

the Russian Emperor Nicholas I (1854), which stated "... begin to drain the marshes, considering this a matter of paramount importance and the first step towards universal blessing ... ". Organized carrying out of drainage works in Polissia began only in the early 70's of the XIX century. In 1872, the government commission, which set out to study the current agricultural situation in the northern and western provinces of Russia, which included the territory of the modern Rivne region. The Commission came to the conclusion that agriculture largely depends on the situation of livestock, which is not developing sufficiently due to the weak feed base (Zhylynskyi, 1899). At that time, huge areas of potential grasslands and pastures were under constant bogs (Kozlova, 1982; Korotun, 1998). It was also noted that "drainage of marshes is a measure necessary in the provinces of the northwestern and western bands of Russia". It was also noted that in certain provinces, including Volyn, "standing water, occupying enormous areas, harmful to the climate, spoil the forest, complicate agriculture and impede the development of livestock – the necessary share of agriculture in these places" (Detsyk, 1981).

The object of research is the system "environment – health of the population". The choice of the object of research is due to the negative progressive dynamics of the health status of the population of the region. Rivne region is characterized by a specific medical-demographic and ecological and radiological situation after the Chernobyl disaster (the northern districts of the region suffered).

The subject of the study is the medical and ecological basis of the health of the population of the Rivne region. The patterns of formation of the population's health in the spatial-temporal dimension in accordance with environmental factors are studied. The ecological factors for determination with medical and demographic situation are investigated.

3. Materials and Methods

The research uses general scientific methods, among them traditional (synthesis, analysis, comparisons, methods of induction, deduction, observation, abstraction, generalization) and modern (system analysis and synthesis). The most commonly used and universal is the systematic method, since medical and geographical research is inherently complex. The methodological basis is made up of special scientific methods: medical and geographical description, medical ecological mapping, cartographic modeling, medical-ecological modeling, medical-ecological forecasting, etc. (Kushniruk & Volkova, 2019).

We were asked to carry out medical-geographical research of the territory of the Rivne region for the purpose of assessing the health and environmental risks. The goal is to solve the problems of calculating the correlation be-

tween the indicators of morbidity and the structure of mortality with indicators of environmental pollution. In this paper, we will focus on solving the problem of studying the relationship of soil contamination with radionuclides with specific nosological units.

The obtained numerical results are based on proven conclusions of such sciences as system analysis, probability theory, mathematical statistics.

4. Results and Discussion

In determining the medical-ecological risk of the territory among a complex of natural indicators and anthropogenic factors of environmental impact, we included a specific violation of the quality of the environment in the north of the Rivne Oblast after the Chernobyl disaster (Kushniruk, 2011a, b).

As a result of the Chernobyl accident in 1986, 6 northern districts (Bereznivskiy, Volodymyrets, Dubrovysky, Zarychnensky, Sarnensky, Rokytnivsky) with a population of 398,700 (including 113,500 children) were radiation contaminated (Kushniruk, 2011a, b).

Soils Rivne Polissya are characterized by a high transition factor (up to 40%) of radiocaesium from the soil to the root system of plants. As a result, the doses of the internal (incorporated with food) radiation of the population of the affected areas of the Rivne region are the highest among the population of Ukraine.

After the accident at the ChNPP, a significant dose load was formed due to radioactive iodine. This is due to the fact that the Polissya zone is characterized by insufficient natural iodine in food and water, so the thyroid gland of the inhabitants has captured radioactive iodine in large quantities.

Subsequently, the main dose load was cesium and strontium, which entered the body with food, especially dairy products of local origin, berries and mushrooms.

At present, the main radioactive elements remaining in the soils of the northern regions of Rivne oblast are: cesium-137; strontium-90; isotopes of plutonium (Fig. 1).

To assess the impact of radiological contamination, we conducted studies to identify the level of soil contamination by radionuclides and the level of morbidity of the population to endocrinological diseases.

The peculiarity of the formation of radiation doses of the population living on contaminated radionuclide territories is prolonged external and internal irradiation, mainly due to long-lived radionuclides of cesium, strontium, supplementing formed doses of the early after an emergency, causing accumulated dose of radiation by the human body.

According to the statistics (Reports on the state of the environment in the Rivne region, 1986-2017), a chart of

the total was constructed accumulation of radiation dose by population (Fig. 2).

We have been conducting research on the connection of diseases of the endocrine system (Indicators of health of the population and the activity of medical institutions of the Rivne region, 1986-2017) and contamination of soils by radionuclides.

Accordingly, the correlation coefficient between the values of total soil contamination and the incidence of diseases of the endocrine system in the respective areas is 0.8 (Kushniruk, 2011a, b).

On the basis of the data, the mapping of the distribution of the levels of primary disease for diseases of the endocrine system was constructed (Fig. 3).

The correlation coefficient between the total dose of radiation accumulated by the population since 1986 and the incidence of diseases of the endocrine system in the areas concerned is 0.87 (Kushniruk, 2011a, b).

The results of the study suggest a high correlation between soil contamination by radionuclides of territories (especially the northern ones) in the Eastern part of the Southwest region of Ukraine and the incidence of endocrine diseases in the regions concerned.

Next, studies were conducted to determine the prevalence of blood diseases with radiological indices. The correlation coefficient of the prevalence of blood diseases and the total radiation dose accumulated by the population is equal to 0.72 (Kushniruk, 2011a, b). The spatial distribution picture is similar to the levels of radiological contamination of soils.

According to individual indicators of soil contamination, the correlation coefficient is 0.75, and in some years the prevalence of blood diseases and soil contamination with plutonium isotopes is correlated with a factor of 0.82.

Studies have also been conducted to determine the incidence of digestive organs and levels of soil contamination with radionuclides. The correlation coefficient of the total soil contamination with radionuclides and the incidence of diseases of the digestive system is 0.84 (Kushniruk, 2011a, b).

On the basis of research, a mapping scheme for total soil contamination with radionuclides and disease incidence of diseases of the digestive system was constructed (Fig. 4).

The spatial distribution of levels of primary morbidity for diseases of the digestive system is similar to the total contamination of the soil with radionuclides (corresponding to the total accumulation of radioactive radiation by the population).

As you can see, not only endocrinological diseases and blood diseases have a determination with radiological indices, which was known for a long time, but also those, at first glance, independent of irradiation of nosology, as diseases of the digestive system.

This can be explained by the fact that more than 90% of the accumulated dose of radiation in the affected areas is

RADIOACTIVE CONTAMINATION OF SOILS

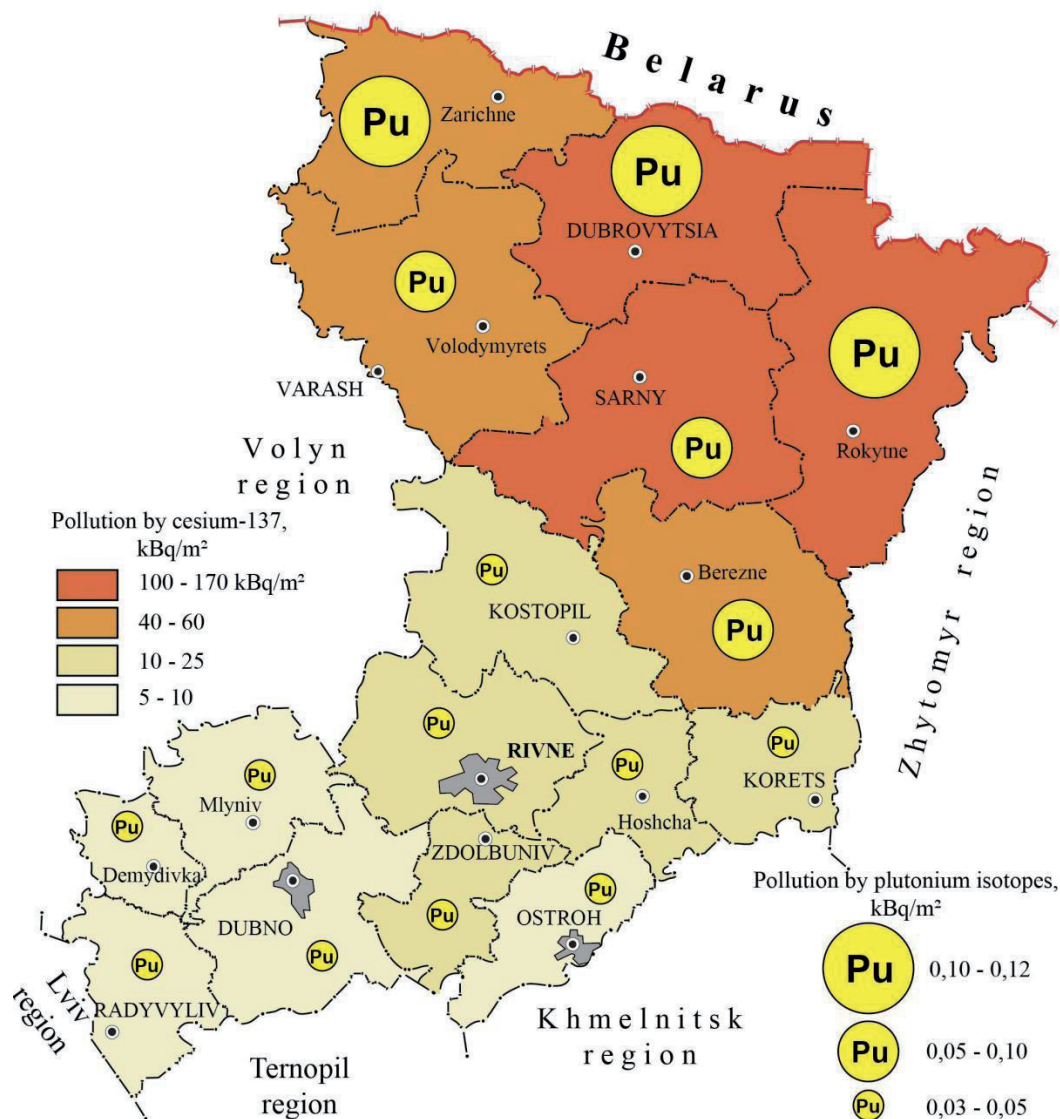


Figure 1. Radioactive contamination of soil, kBq / m²

received through internal radiation, namely, because of the consumption of radioactive contaminated food that enters the body through the digestive system, which increases the risk of ulcer, gastroduodenitis, pancreatitis, cholecystitis, etc.

Thus, we identified the main indicative nosological units of the radiological component of the medical and ecological risk of the territory, which included endocrinological diseases, blood diseases and hematopoietic organs. Diseases of the digestive system, although correlating with the radiological condition of the territory, are still more dependent on factors such as the quality of

drinking water and the quality of food products (Kushniruk, 2011a, b).

As for the study of the dynamics of indicative nosological units of the radiological condition of the territory, we analyzed the levels of prevalence of endocrine system diseases and blood diseases and blood diseases for the period of 1990-2017 in the context of 15 districts of Rivne oblast (among all age groups per 1000 inhabitants).

In the systemic approach, in relation to Chernobyl disasters, the dependence between the dose of irradiation and the biological response of the irradiated population is taken into account, but synergistic effects (socio-psychological



Figure 2. Total dose of irradiation of the population (average per district with the certification of settlements), cGy

stress, radiation effects on primary health indicators, the influence of other anthropogenic factors, ethnic peculiarities etc.) and prolonged irradiation in time (Kushniruk, 2011a, b).

As a result, separate nosological units have different dynamics, but all that we refer to as indicative radiological state of the territory, tend to grow. The dynamics of various diseases varies depending on the body's ability to compensate-decompensation effects, which are different (as well as resistance) with different classes of diseases.

Thus, the dynamics of oncological morbidity has not yet been isolated in contaminated territories on the general background of slow growth (the peak of cancer morbidity is projected for 2030-2040 years). But, at the same time, the disease of the endocrine system is characterized by an increase in the dynamics of morbidity in the northern regions of the region (Fig. 5). For southern areas, there is also an increase in the dynamics of morbidity, albeit much lower, due to a higher concentration of industry, low forest cover, high anthropogenic pressure and migration from the northern regions.

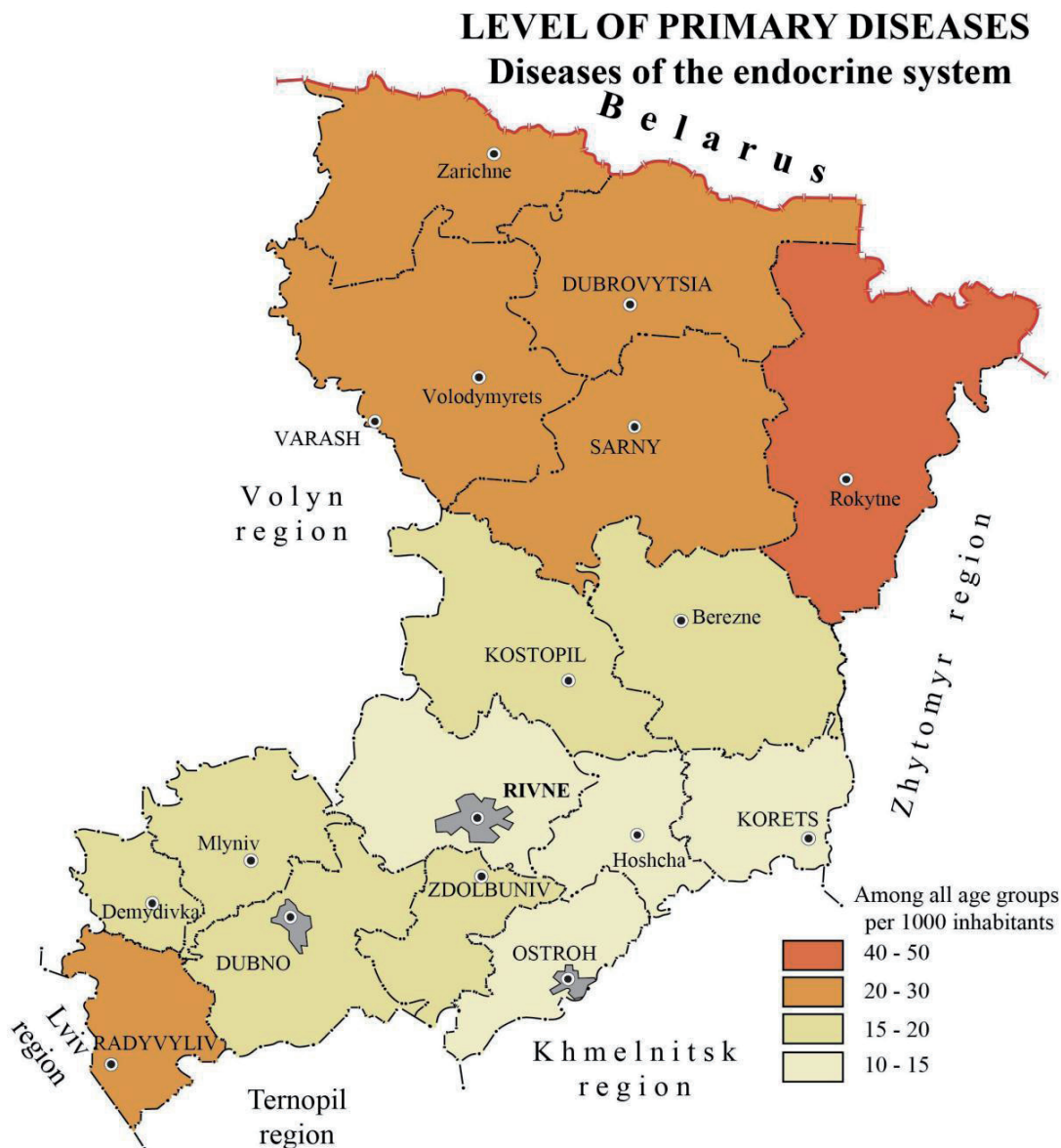


Figure 3. Primary incidence of diseases of the endocrine system (among all age groups per 1000 inhabitants)

The dynamics of the prevalence of blood diseases has a similar pattern (Fig. 6). Only the phenomenon of decompensation (excess of compensatory mechanisms of the organism) manifested earlier – from 1991-1992 eg. due to the more rapid pathogenesis of diseases that belong to this nosological class.

Since more than 90% of the radiation dose accumulation results in internal exposure as a result of eating foods grown on contaminated soils, and a forecast of soil contamination levels with radionuclides could not be positive (without extensive chemical melioration and recultivation), further increases in the prevalence of ra-

diologically dependent diseases in the northern regions against the background of their stable prevalence in the southern regions of Rivne region (Kushniruk, 2011a, b).

If, for a certain number of nosological units, the weight factor of such an ecological factor as the radionuclide contamination of the soil is minimal, then for endocrinological diseases, blood diseases, diseases of the digestive system, oncological diseases, congenital developmental abnormalities, chromosomal aberrations, etc., the factor taken into account in determining the medical-ecological risk the territory will be maximum (Kushniruk, 2011a, b).

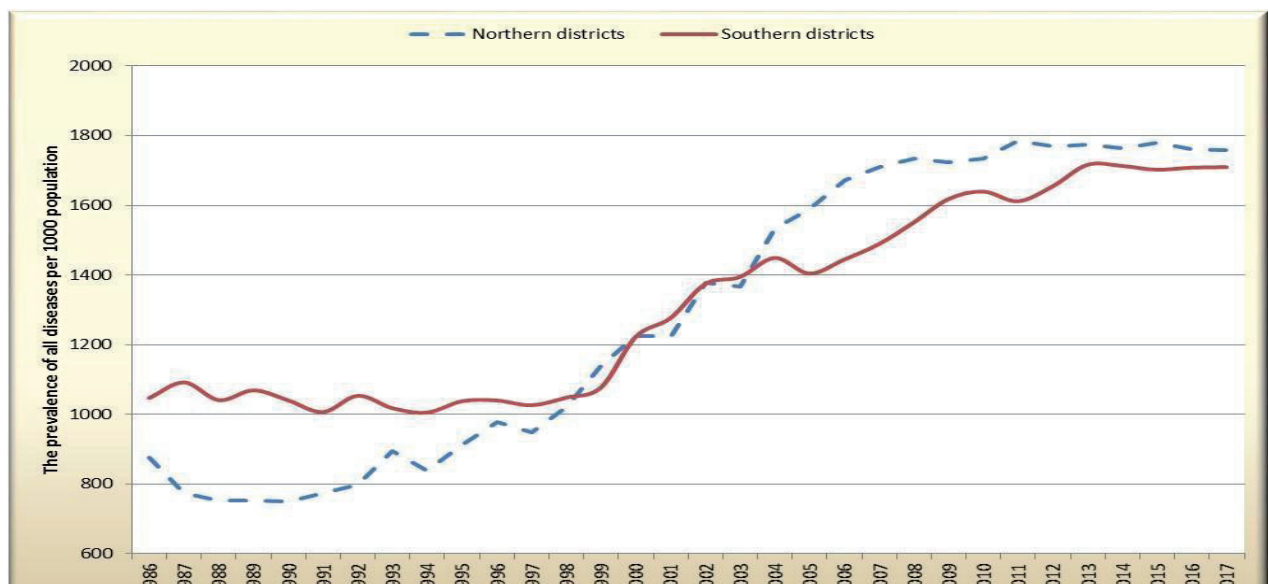


Figure 5. Dynamics of prevalence of endocrine diseases

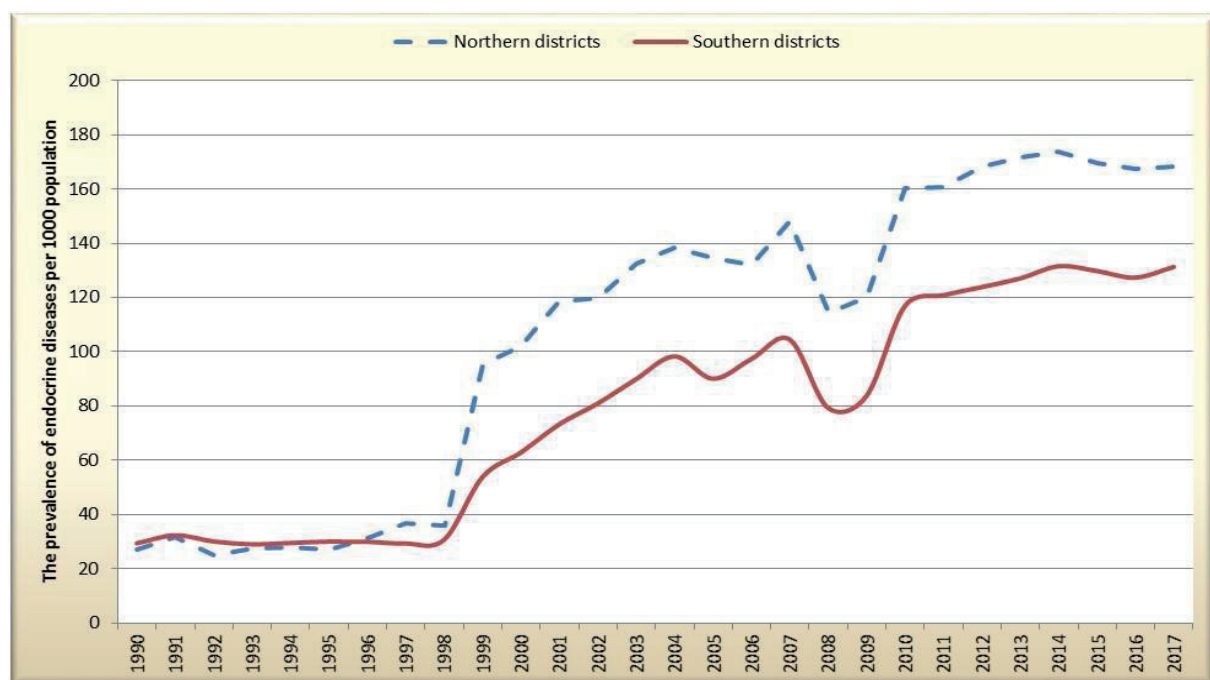


Figure 6. Dynamics of the prevalence of blood diseases and hematopoietic organs

Such dynamics of the indicator nostologists determined by us in the radiological state in a certain way also influenced the dynamics of the prevalence of all diseases in the Northern and Southern regions of Rivne region (Fig. 7).

Due to more intensive growth of endocrine diseases, blood diseases, diseases of the digestive system, congenital anomalies of development and chromosomal aberrations, the northern regions that had initially (due to lower industrial load and the best natural recreational indicators) lower indicators of the overall prevalence of all diseases, since

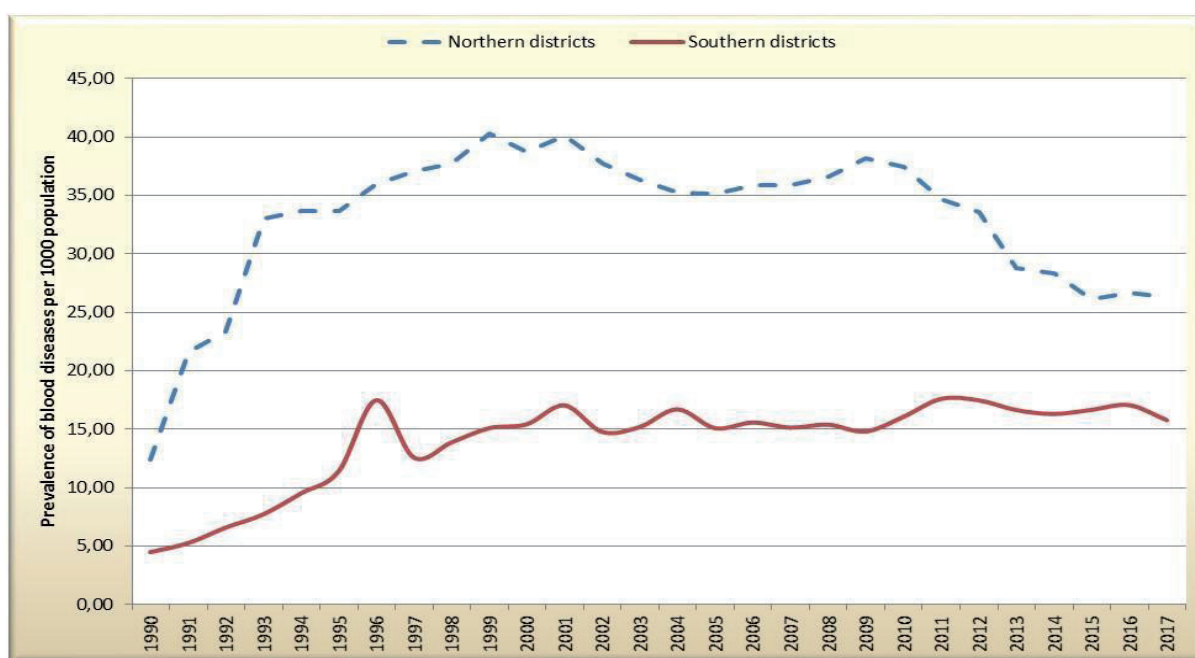


Figure 7. The dynamics of the prevalence of all diseases

the mid- the southern regions overtaken, and with the beginning of the 2000s they overtook.

5. Conclusions

It should be noted in conclusion that although natural factors in the north of the Rivne region affect the reduction of health and environmental risks, unfortunately, after the Chernobyl catastrophe, we have a degradation in terms of environmental risk for living in our best natural areas. Given the phenomena of compensation and decompensation of the body of harmful effects is a gradual accumulation of destructive changes that occur only a few years after the onset of influence. In the case of cancer, this interval increases to 20-25 years. As a result, we are now seeing only the beginning of an increase in cancer in the affected areas.

The theoretical value of the obtained results is to deepen theoretical knowledge about the existing interconnections in the system “environment – health of the population”.

The practical value of the results of the study is to apply the method of express assessment of the medical and geographical condition of the territory for the development of plans for the development of the region in accordance with the minimization of health and environmental risks for the population.

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